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EXPERIENCE IN USE OF GYROTHEODOLITES IN INSPECTION OF POINTS IN A GEODETIC NET

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13. ABSTRACT

The use of gyrotheodolites for azimuth determinations on orienting points is described. The basic virtues of gyroscopic orientation are speed and independence of determination of azimuths and the capability of carrying out work independently of weather conditions, time of year and day, and physico-geographic characteristics of the operating area.

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II

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ENGLISH TITLE: EXPERIENCE IN USE OF GYROTHEODOLITES IN INSPECTION OF POINTS IN A GEODETIC NET

FOREIGN TITLE: OPYT PRIMENENIYA GIROTEODOLITOV PRI OBSLEDOVANII PUNKTOV GEODESICHESKOY SETI

AUTHOR: N. P. Astakhova

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NOTICE

III

Since 1960, our business has carried out a large volume of work in inspection and restoration of old points of a geodetic net. Two orientations (azimuthal) of the point at a distance from the center of the mark of not less than 250 m were established for the points examined.

Exterior marks on many triangulation points were not maintained and, frequently, azimuths on orienting points had to be given by the astronomical method. However, a large number of overcast days in the operating area (there were not more than 10 clear days in a month) hampered astronomical observations considerably. Under these conditions, GI-B2/E (MOM Company, Hungary) gyrotheodolites were used for azimuth determinations on orienting points.

The basic virtues of gyroscopic orientation are speed and independence of determination of azimuths, the possibility of carrying out work independent of weather conditions, time of year and day and physico-geographic characteristics of the operating area. All of this permitted the enterprise to carry out a considerable volume of work in examination of triangulation points under conditions of 70-80% forested areas, with a great many swamps and in bad weather.

Observations in 1969 were carried out in a period from April to October, at air temperatures of from -4 to +21°, both day and night, in clear, overcast, rainy and snowy weather.

Two expeditions of the enterprise were organized in two teams, led by engineers. The composition of the teams is shown in the table.

There were two gyrotheodolites per team. Three teams were supplied with ATL truck tractors, and one with a DT-54 tractor for transportation to the working area. Experience shows that the tractors should not be used for transporting gyrotheodolites, since they have poor shock absorbers and low speed, and positioning gyrotheodolite sets in them is hampered. The ATL truck tractor proved to be more suitable for cross country conditions.

1 Состав бригады	2 Экспедиция 1	3 Экспедиция 2
Инженер-наблюдатель 4	1	1
Помощник наблюдателя 5	—	1
Рабочий 2 разряда 6	2	1
Водитель транспорта 7	1	1

Key:
1. Team composition
2. Expedition 1
3. Expedition 2
4. Engineer-observer
5. Assistant observer
6. Class 2 operator
7. Truck driver

The work of the gyrotheodolite teams was organized in the following manner. On expedition 1, these teams only determined azimuths on points restored by engineers in the preceding year at the beginning of the season. In the second half of the season, they carried out a whole complex of inspection work. This use of gyrotheodolites was of low effectiveness. On expedition 2, for more effective use of gyrotheodolites, a special team was created, which restored the points examined, and the gyrotheodolite team only determined azimuths and registered orienting points officially.

Before going out to the field, as well as not less than once in three months, the correction of each gyrotheodolite was determined in the initial orientation direction. One of the expeditions used the site of a class 3 triangulation for this, and the other an astronomical azimuth of a line, especially observed to an accuracy of $\pm 1.4''$. The gyrotheodolite correction was determined in the course of one to two days on four to nine start-ups, on each of which four sensitive element reversing points were observed. After each start-up, the instrument leveling was "disconcerted" by the elevating screws and, before the following start-up, was established anew. The gyrotheodolite correction on each start-up was calculated as the difference between the astronomic and gyroscopic azimuths of the initial direction. The period of the free oscillation of the sensitive element was measured to an accuracy of 0.1" during determination of the correction on each start-up. The free oscillation period of all gyrotheodolites was stable during the entire time of the operation and did not differ from the rating plate value by more than 0.3". The stability of the gyrotheodolite corrections was determined by means of comparing their mean values on each determination with the rating plate value. Deviations reached no more than 15".

The orienting directions were determined by two measurements of the direct azimuth, by either two gyrotheodolites starting up in succession, or one gyrotheodolite with two start-ups (depending on the team equipment).

Four reversing points were observed on each start-up and the value of the equilibrium positions of the forced oscillations of the sensitive element were determined from them. The equilibrium position of the sensitive element free oscillations, as well as the free oscillation period, were determined before and after each start-up. The value of the free oscillation equilibrium position after the start-up was used for data processing.

Directions to the marks, established over the centers of the orienting points, were measured before and after start-up. Discrepancies between azimuth values determined on two start-ups reached no more than 40". Analysis of the results of measurement of the series of azimuths showed that this tolerance was easily maintained. Fluctuations in the values of angles between directions to orienting points, obtained as an azimuth difference in each start-up, reached no more than 10".

Azimuth determination by two gyrotheodolites gives more reliable results, since the work of both observer and instrument are checked in this case. Azimuth determinination by two start-ups of one gyrotheodolite, adhering to the tolerances in the measurement processes, permits a judgement, mainly, of the work of the observer, but does not fully characterize the operation of the gyrotheodolite. Therefore, in such a method, it is necessary to check the stability of the gyrotheodolite correction more often. In the period between determinations of the gyrotheodolite correction (on the initial line, with a known azimuth), its stability is checked by determination of the azimuth on the observed orienting points and comparison of the values obtained with the azimuth values calculated by directional angles taken from the catalogues, as well as by comparison of the azimuth values determined by the sun, with azimuths determined by the gyrotheodolite. Thus, in determination of 228 azimuths by gyrotheodolite No. 909 459, check determinations were made on 27 observed orienting points, and on 6 points, a comparison was made of the azimuths measured by gyrotheodolite with azimuths determined by the sun, which gave the possibility for systematic checking the stability of the gyrotheodolite correction. Two start-ups were made in check determinations. Four sensitive element reversing points were observed on each start-up.

Upon completion of the work, the mean quadratic error of azimuth determination by the gyrotheodolite was calculated, using the results of observations, according to the formula

$$m = \pm\sqrt{\frac{\Sigma\Delta^2}{2n}}.$$

where Δ is the difference between azimuth values determined by either different gyrotheodolite sets or by two start-ups of one gyrotheodolite

and n is the number of azimuths determined.

The mean quadratic error, calculated from the results of determination of 170 azimuths by two gyrotheodolites, was equal to ±11.4", and from the results of determinations of 120 azimuths by one gyrotheodolite, ±10.7".

The accuracy obtained agrees well with the technical data on the instrument and significantly exceeds the required accuracy of orienting point azimuth determinations.

The ATL truck tractor storage batteries and 6-ST-54 and 6-ST-68 storage batteries were used as gyrotheodolite power sources. The truck tractor storage batteries provide the necessary voltage, and their capacity is two times greater than the capacity of the 6-ST-54 and 6-ST-68 storage batteries. They are recharged on movements and provide electric power stability. In moving gyrotheodolites to points by hand, the lighter 6-ST-54 and 6-ST-68 storage batteries were used, which discharged after 15-18 start-ups. A VSA-10 current converter connected to the electric system, was used for charging in populated places.

It takes an adequately qualified team 2 hr 30 min for determination of two azimuths on a point while working with two gyrotheodolites. Working with one gyrotheodolite, it takes 2 hr 05 min. Taking into account the time taken in movement and switching, on measuring distances to orienting points, establishing and centering marks and officially registering orienting points, 0.7-1.0 team days is taken up on one point.

Effective arrangement of the instruments has great importance for acceleration of work on a point. It is desirable that the power pack and storage batteries be located so that all adjustments, switching and checking of instruments can be carried out without leaving the gyrotheodolite. The legs of the tripod are best extended to such a length that the optical axis of the telescope and autocollimator scale are at the observer's eye level when he is standing at full height. In the autumn and spring periods (when the ground is frozen) and in the summer, when the ground is loose, it is necessary to use the metal spikes included in the set, which provide good stability for the instrument. The rigid cables connecting the gyrounit with the power pack repeatedly get out of order during operations in nearly all gyrotheodolites. It is desirable to replace them with elastic ones.

It should be noted in conclusion, that the use of gyrotheodolites under summertime conditions in 1969, with lingering rains and a small number of sunny days, permitted both expeditions to complete the plan of examination of points in a geodetic net, which would have been impossible with the use of astronomic methods only. With proper organization of the work, use of gyrotheodolites significantly accelerates the process of examination of points in a geodetic net, especially under poor climatic conditions.

Analysis of the results of azimuth measurements on orienting points, completed in 1968 and 1969, gives a basis for drawing a conclusion that the use of gyrotheodolites for azimuth measurements by the enterprise permits them to be obtained with an accuracy not lower than ±15".

For the purpose of increasing the effectiveness of the use of gyrotheodolites, it is necessary to organize the work of the gyrotheodolite teams so that all superfluous secondary work is eliminated. Transportation ··

which permits the instrument to be carried directly to the point should be given to gyrotheodolite teams (in order to avoid carrying gyrotheodolite sets by hand).